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AUTHOR Rock, Donald A.; Pollack, Judith M.

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ABSTRACT

This brief report documents growth in mathematics achievement during the high school years and its relationship to differential course taking in mathematics. Data are taken from the National Education Longitudinal Study of 1988 (NELS:88), which was designed to monitor the transition of the nation's 1988 eighth graders as they progress from junior to senior high school and on to postsecondary education and the world of work. Analyses were based on slightly more than 10,000 NELS:88 students. It was found that slightly over 61% of high school students do not go beyond the algebra 2/geometry level of coursework, and only approximately one of nine students takes a calculus course in high school. About one in four never goes beyond algebra 1. Growth in mathematics achievement appears to be greater in the first two years of high school compared to the last 2 years. Students who take the more advanced courses show greater gains in mathematics, and, after they move to the precalculus level, they show greater gains in conceptual understanding and problem solving skills. A technical appendix reviews survey methodology. Four figures and four tables present survey findings. (Contains nine references.) (SLD)

NATIONAL CENTER FOR EDUCATION STATISTICS

Statistics in Brief

May 1995

Mathematics Course-Taking and Gains in Mathematics Achievement

Contact:
Peggy Quinn
(202) 219-1743

Authors:
Donald A. Rock
Judith M. Pollack
Educational Testing Service

Introduction

This brief report documents growth in mathematics achievement during the high school years and its relationship to differential course-taking in mathematics. The data for this analysis are taken from the National Education Longitudinal Study of 1988 (NELS:88). Longitudinal studies such as NELS:88 are important from a policy viewpoint because they provide information on the relationship between gains in achievement and course-taking behaviors. Cross-sectional studies such as the National Assessment of Educational Progress (NAEP) cannot make this connection.

NELS:88 was designed to monitor the transition of the nation's 1988 eighth graders as they progress from junior to senior high school and then on to postsecondary education and the world of work. Students were tested in the spring of their 8th-grade year, and then again 2 and 4 years later, when most participants were in 10th and 12th grades. The analyses reported here were carried out on the slightly more than 10,000 NELS:88 students who had high school transcripts as well as test scores on all three occasions. While this analysis required complete transcripts in order to determine the highest level of mathematics taken, dropouts were included if they had transcripts that were complete up to the point at which they dropped out of school, and if they had mathematics test scores for all three time points.

Gains in Mathematics

Academic growth in mathematics is defined here as gains in tested achievement in this content area. The content of the mathematics tests spanned topics covered in basic mathematics through algebra 2 and geometry, but did not include material typically taught in pre-calculus or calculus courses. At each time point, different test forms were developed to optimize accuracy of measurement for the expected ability level of the students. The seven test forms were put on the same scale so that comparisons of scores between time points could be made. For more

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details about the test forms and the scaling procedure, see the technical appendix on page 7.

Gains in mathematics are presented for the 8th to 10th grade, and then for the 10th to 12th grade transition. In addition, the relationship between exposure to specific kinds of coursework and relative gains is also examined.

Course-Taking Behaviors

Gains are shown for students grouped into categories according to the highest level of mathematics courses taken in 9th through 12th grade. A small number of students were not included in the analysis because the courses reported on their transcripts could not be classified in any of the categories that were used. Students were classified into five categories described below:

Basic: no coursework beyond business, consumer, vocational math; remedial math; pre-algebra

Algebra 1: highest level is algebra 1 or elementary algebra

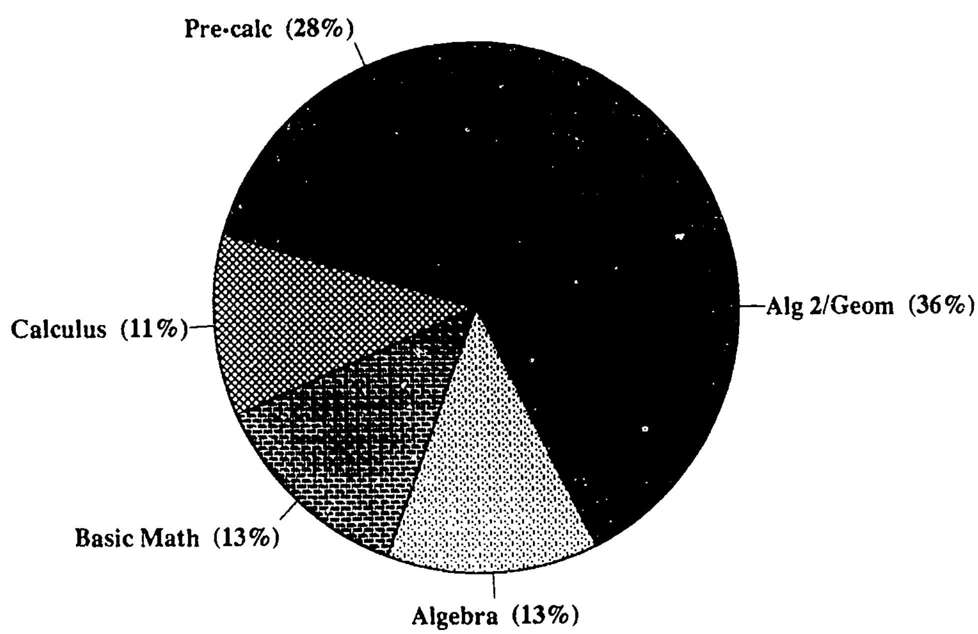
Algebra 2/Geometry: algebra 2 or intermediate algebra; plane and/or solid geometry

Pre-calculus: advanced coursework beyond the algebra 2/geometry level, including at least one course in algebra 3, trigonometry, analytic geometry, linear algebra, or probability and statistics

Calculus: calculus, advanced placement math

Figure 1 presents the percentages of students in groups defined by the highest level of mathematics course taken.

Figure 1:
Students Grouped by Highest Level of Math Course Taken in High School



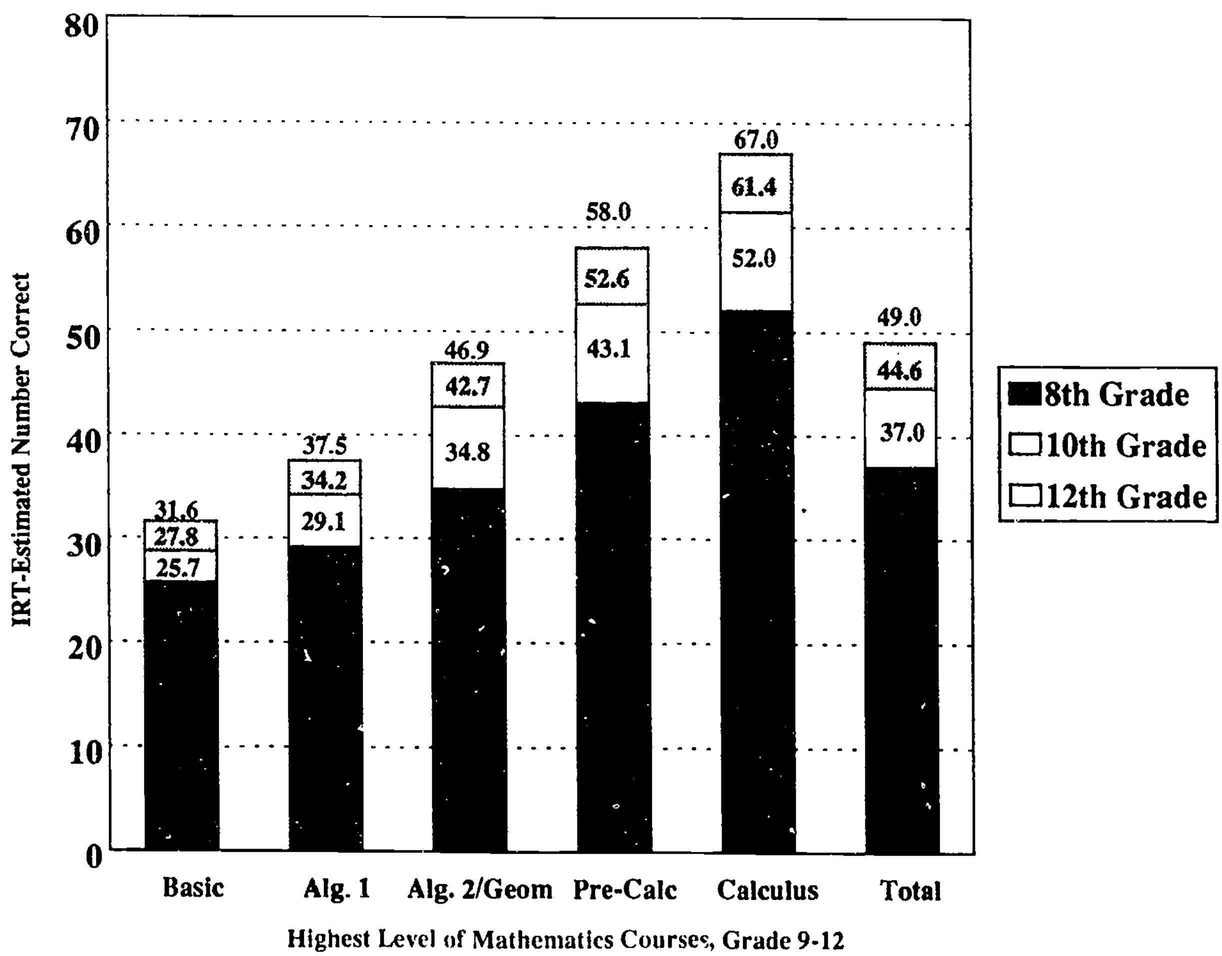
Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1992 Second Followup High School Transcripts.

For example, for 11 percent of the students, the highest level of mathematics course taken was a calculus course, and for 27 percent of the students the highest course taken is a pre-calculus course. Over 25 percent of the students never took a course beyond algebra 1 during their last four years of secondary education. Slightly over 61 percent never took any mathematics courses beyond algebra 2 and/or geometry. Table 1 in the Appendix shows that differences in course-taking patterns for males and females were small.

Mathematics Gains and Course-Taking Behavior

Figure 2 presents mathematics gains for the five course-taking categories and for the total core sample. The stacked histograms show the students' 8th, 10th, and 12th grade score by the highest course level categories. Inspection of the total column indicates that on average there were significantly greater gains made between the 8th and 10th grade than were made between the 10th and 12th grade in the material covered by the NELS:88 mathematics tests.

Figure 2:
Average Mathematic Scores by Course-Taking and Grade



Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1992 Second Followup High School Transcripts.

The larger score gains in the first half of high school have different meanings for different groups of students. Many students take no math courses in the last year or two of high school; their largest increases in mathematics achievement coincide with the period of time in which they took most of their courses.

At the other end of the scale, the students who continue their study of mathematics through pre-calculus or calculus have made their greatest gains in arithmetic, algebra, and geometry in the early years, and are studying more advanced material in their last year or two of high school. The NELS:88 mathematics tests were not designed to measure achievement in advanced mathematics. Part of the differential gain in favor of the 8th to 10th grade may be due to the fact that even those students who take one or more pre-calculus courses do not necessarily continue to take mathematics courses each semester of their 11th and 12th year of schooling. Approximately one-fifth of this group finished their mathematics sequence by the end of their 11th year. However, these same students who take the pre-calculus courses tend to have taken mathematics courses every semester of their 9th and 10th years in school.

Only those students whose highest level course was pre-algebra (basic math) showed equivalent gains between 8th and 10th and 10th and 12th grade. Their gains were quite small in both periods, however.

Figure 2 shows that even before entering high school, the students who would eventually take higher level courses already had substantially higher average achievement scores than did those who would later stop before taking advanced mathematics. However, the focus of this report is on relative differences in score gains for the course-taking categories, and not on differences in initial status. A comparison of the relative amount of gain by course-taking categories shows that students who eventually took the higher-level courses (algebra 2/geometry up to calculus) showed consistently greater gains during the 8th- to 10th-grade transition than did their counterparts who did not. With respect to the 10th- to 12th-grade transition, those students whose highest level courses included pre-calculus or calculus courses showed significantly more growth in mathematics skills than did those who finished their mathematics education with algebra 2 or geometry or even lower level courses. Similarly, those students whose highest course level included algebra 2 or geometry gained significantly more during their junior and senior years than the basic math students.

The average math scores and gains are broken down by student sex in Table 2a. Both male and female students made their greatest gains in mathematics achievement in the first two years of high school. Score gains for the two groups were quite similar during this interval. However, males showed slightly more improvement in scores than did females in the last two years, resulting in greater gains over the four year interval. Males and females who did not go beyond basic mathematics had very similar average scores and achievement gains. The groups of students whose highest mathematics course was algebra 1, algebra 2/geometry, or pre-calculus had a consistent pattern of slightly higher eighth grade average achievement for males, similar amounts of gain for males and females in the first two years of high school, and higher gains for males than for females in the last two years and overall. Due to small sample sizes, these differences were statistically significant only for the male advantage in gain over four years, and in the last two years of high school, for the algebra 2/geometry and the pre-calculus groups.

Type of Gain and Course-Taking Behavior

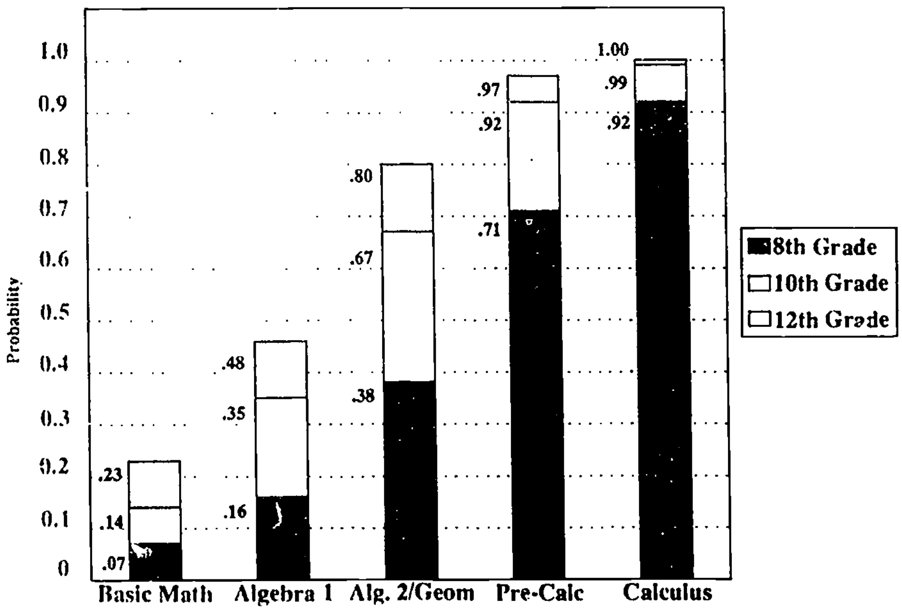
So far we have just looked at the amount of gain--now we want to look at the level at which that gain is taking place and how that level is related to math course-taking and year in school. While there were differences found in the amount of mathematics gain both by course-taking behavior and year in school, there were also differences in the quality or type of growth taking place. That is, while students may be in the same cohort they are taking quite different courses which in turn target different levels of mathematics skills. For example, students who stop taking math after basic or algebra 1 - level courses are typically learning skills which improve their computational skills but have little direct impact on their growth in more complex mathematical concepts and/or ability to successfully carry out complex problem solving exercises.

In addition to the standard gain score analysis, the NELS:88 mathematics test was designed to provide criterion-referenced interpretations which would allow one not only to estimate the amount of growth taking place but also to indicate what type of skills are being developed. The criterion, referenced interpretations are based on students demonstrating proficiencies on clusters of items that mark five ascending points on the test score scale. The five ascending points on the scale mark increasingly higher levels of mathematical complexity (Rock & Pollack, 1995). The items that make up these clusters exemplify the skills required to answer successfully the typical item located at these points along the scale. These proficiency scores are reported in terms of the **probability** that a student is proficient at a particular skill level. Aggregated over all students in a group, the average probability of proficiency is equivalent to an estimate of the proportion of students in the group who have mastered the particular skill. Additional detail on the scoring and interpretation of the proficiency probabilities may be found in the technical appendix on page 7, or in the Psychometric Report (Rock & Pollack, 1995).

Performance on two of the five skill levels is reported here. The first (level 2) requires proficiency in procedural knowledge of operations with decimals, fractions, powers, and roots. The second criterion-referenced skill level reported here (level 4) requires understanding intermediate level mathematical concepts and the ability to solve multi-step word problems.

Figures 3 and 4 show the relationship between course-taking categories and gains in the **probability** of being proficient at two different levels of mathematical skills.

Figure 3:
Probability of Being Proficient in Level 2 Operations
By Grade and Highest Level of Math Taken in High School

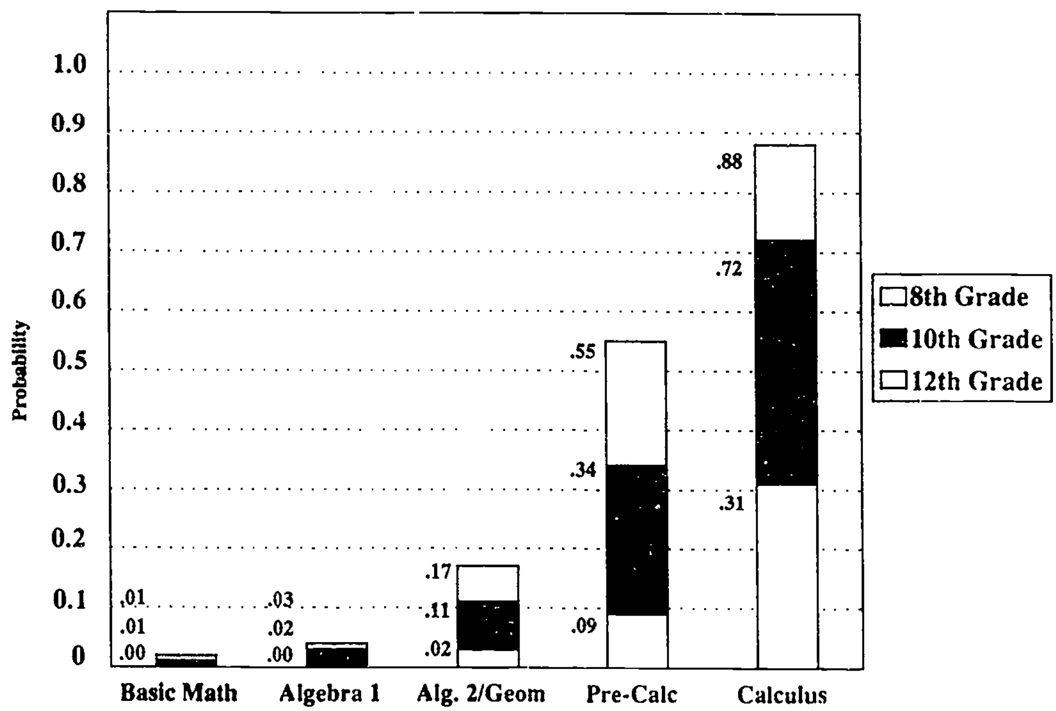


Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1992 Second Followup High School Transcripts.

Figure 3 presents a histogram showing the probability of being proficient in the areas of decimals, fractions, powers, and roots by grade in school (8, 10, and 12) and category of course-taking. For example, figure 3 shows that the average student in the algebra 2/geometry category had a probability of .67 of being proficient in 10th grade on items involving decimals, fractions, powers, and roots. Students who were in the pre-calculus grouping had a probability on average of .92 of being proficient at this skill level in 10th grade. Inspection of figure 3 indicates that the basic math and algebra 1 students continue to grow in these skills at about the same rate between grades 8 and 10, and grades 10 and 12. The remaining students show significantly greater growth in their probability of being proficient at these relatively low level procedural skills between 8 and 10, than between grades 10 and 12.

Figure 4 presents changes in the probability of being proficient at the conceptual understanding and problem solving skill level by course-taking category and grade in school.

Figure 4:
Probability of Being Proficient in Level 4 Problem Solving
By Grade and Highest Level of Math Taken in High School



Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1992 Second Followup High School Transcripts.

Inspection of figure 4 shows that students in the relatively low level courses, basic math or algebra 1, show negligible gains in this area during the four years of high school, unlike the students grouped in the remaining higher level course categories. Students in the pre-calculus and the calculus course groupings show significantly greater gains in this area than do the students in the algebra 2/geometry category. The pattern of these gains suggest that there is little growth in the understanding of intermediate mathematical concepts and multi-step problem solving skills in the absence of relatively advanced coursework.

Summary

When student gains in tested mathematics achievement were cross-classified by grade in school and highest level of mathematics course taken it was found that:

- Slightly over 60 percent of high school students do not go beyond the algebra 2/geometry level of coursework.
- Approximately 1 out of 9 students take a calculus course while in high school.
- About 1 out of 4 students never go past algebra 1 in their high school career.
- Growth in arithmetic, algebra, and geometry achievement appears to be greater in the first two years of high school than in the last two years for almost all course-taking categories.
- Students who take the more advanced mathematics courses show greater gains, both between 8th and 10th grade, and between 10th and 12th grade, than those taking the more basic courses.
- Students who do not take advanced courses (those whose highest level course is basic mathematics, algebra 1, or algebra 2/geometry) make greater gains on test items dealing with computational skills such as working with decimals, fractions, roots and powers than they do on higher level skills.
- Students in the advanced courses, who already had high levels of proficiency in basic skills at the beginning of high school, make larger gains on test items requiring conceptual understanding and problem solving skills. In fact, significant growth in these areas does not occur until students move into the pre-calculus level of coursework.

Technical Appendix

Design of NELS:88. The National Education Longitudinal Study of 1988, or NELS:88, is a ten-year data collection project sponsored by the U.S. Department of Education of the National Center for Education Statistics. The aim of the study is to collect comprehensive information on the family, school, and community experiences of a national cohort of 1988 eighth graders. The study began with a national probability sample of more than 1,000 eighth grade schools and more than 24,000 eighth grade students. Data were collected from the students, their parents, and their teachers and school administrators in 1988. The original group of students was resurveyed in 1990, 1992, and 1994; subjects were included regardless of whether they were still enrolled, graduated, or dropped out. Additional data were collected from teachers and school administrators in 1990 and 1992; parents were resurveyed in 1992. The students were administered achievement tests in mathematics, science, reading and social studies. Students and dropouts were interviewed and tested again in 1990 and 1992. Transcript data spanning the years of high school were collected for both high school students and dropouts in the NELS:88 Second Follow-up Survey. Transcripts were collected for 17,100 individuals out of a target number of 21,188. A detailed description of NELS:88 design, instrumentation, and responses is found in Ingels, et al. (1994).

NELS:88 Mathematics Tests. There were seven mathematics test forms administered in the NELS:88 survey. All eighth graders took the same 40 item math test, which consisted of about half arithmetic items, with the rest divided among graph reading and relatively easy algebra and geometry questions. In the two later years, three 40-item test forms of different average difficulty were developed and assigned to students on the basis of their performance in the previous administration. Those in the middle half of the score distribution received a middle-difficulty test form, with the highest and lowest scoring students taking a harder or easier form of the test. While arithmetic items continued to be about half of the items on the low-difficulty forms, the middle and hard test forms contained relatively fewer arithmetic items and more geometry and data/probability questions, as well as a few questions in "advanced topics." Material typically covered in pre-calculus or calculus courses is not measured by these tests.

In order to make comparisons between students who took different forms of the test, as well as to measure gain over time, the seven test forms (one in the base year and three in each of the two followups) were put on the same scale. The IRT (Item Response Theory) based scaling procedures are described in detail in the Psychometric Report (Rock & Pollack, 1995). IRT uses the pattern of right, wrong, and omitted responses to the items actually administered in a test form, and the difficulty, discriminating ability, and "guess-ability" of each item, to place each student on a continuous ability scale. It is then possible to calculate the student's probability of a correct answer on any test question that has been calibrated on this scale. The sum of probabilities for a set of test questions is not an integer, but can be interpreted as an estimated count of correct answers. The "IRT-Estimated Number Correct" scores analyzed for this report are estimates of the number of test questions each test taker would have answered correctly out of the total of 81 items that appeared on the seven mathematics test forms.

The proficiency scores provide a means of distinguishing total scores and score gains, as measured by overall IRT-Estimated Number Correct scores, from criterion-referenced measurements of specific skills. At five points along the score scale of the mathematics test, four-item clusters of test questions having similar content and difficulty were identified. A student was assumed to have mastered a particular level of proficiency if at least three of the four items in the cluster were answered correctly, and to have failed at this level if two or more items were wrong. The proficiency levels were shown to follow a Guttman model for nearly 90 percent of the test takers, that is, students passing a particular skill level had also mastered all lower levels; failure at any level indicated non-mastery at higher levels.

Estimates of probability of proficiency for each level were calculated by treating the pass/fail scores for each proficiency level cluster as single items for the purpose of IRT calibration. Since the parameters for the item clusters are on the same scale as the actual items, probabilities of mastery for proficiency levels can be computed based on each student's overall performance in mathematics at each point in time, in exactly the same way as probabilities of correct answers on individual test questions. Averages of the proficiency probabilities, aggregated over groups of students, are analogous to estimates of the proportion of students who had mastered the particular skill. These measures of probability of mastery at each proficiency level are particularly useful in analyzing achievement gains from base year and first follow-up measures. They provide a way of relating students' experiences to improvements in skills that are more specific than the overall mathematics scores.

Analysis Sample. The base sample used in this report consists of the 10,306 students who met the following three criteria: (1) they completed mathematics achievement tests in the 1988, 1990, and 1992 surveys; (2) NELS:88 was able to collect transcript data covering all years during which the students were enrolled in high school; and (3) the transcript-recorded math courses could be classified into the standard categories used in this report.

Variables Used in the Analysis. The *course-taking variables* were constructed by classifying the math courses recorded on the students' transcripts into "levels" of the mathematics curriculum, determining the highest level reached during high school, and merging this information with the students' achievement score records. The NELS:88 Secondary School Transcript file uses a very detailed system of course classification, and a considerable amount of work is needed to collapse the detailed codes into the categories used here. Though not available when this analysis was conducted, the NELS:88 second follow-up public-use data files include variables which summarize the transcript data and make the information more accessible. The codebook variables which compare most closely to those constructed for the present report are named **F2RAL1_C, F2RAL2_2, F2RGEO_C, F2RTRI_C, F2RPRE_C,** and **F2RCAL_C** (total Carnegie units earned, respectively, in Algebra I, Algebra II, Geometry, Trigonometry, Pre-calculus, and Calculus). The classification used in this report differs somewhat from the public-release variables, for two reasons. One is that the public variables include some information for students from whom incomplete transcripts were collected, whereas such students were excluded from the present analysis. A second reason is that the public variables do not distinguish between students who took a course but earned no credit for it, and students who never took the course at all. The present report was interested in whether students had been exposed to a particular level of math course work, and not how well they did in the course.

The composite measure of the "highest course reached" used throughout this report was then constructed by assigning all students who had a course in calculus to the highest level; the remaining cases who had one or more courses of pre-calculus, trigonometry, or statistics to the next highest level; the remaining cases who had one or more algebra 2 or geometry courses to the next highest; the remaining cases who had one or more algebra 1 courses to the next highest; and the remaining cases to the lowest, "basic math" level.

Two kinds of *mathematics achievement scores* are used in this analysis: average IRT-estimated number correct scores, and probability-of-proficiency scores. The average IRT-estimated number correct scores are composite scores that summarize each student's performance across the various content and skill domains of mathematics. The names of the public-use variables are **BY2XMIRR** (base year), **F12XMIRR** (first follow-up), **F22XMIRR** (second follow-up). The probability-of-proficiency scores measure the likelihood that students are proficient in particular types of mathematical skills. Five skill levels are defined in the NELS:88 files, two of which are used in this report. The lower one is referred to as "level 2" in the NELS:88 documentation, and is defined as the ability to perform simple operations with decimals, fractions, powers and roots. The public-use variables are **BY2XMPP2** (base year), **F12XMPP2** (first follow-up), and **F22XMPP2** (second follow-up). The higher level is level 4 of 5 and is defined as the ability to understand intermediate-level mathematical concepts or having the ability to formulate multi-step solutions to word problems. The public-use variables are **BY2XMPP4**, **F12XMPP4**, and **F22XMPP4**.

The measure of *student sex* used here is codebook variable **F2SEX.**

Sampling Errors. The NELS:88 sampling procedures were designed to produce a sample that would be broadly representative of students across the country from public and private schools, and from many different types of social background. This required a complex classification of all schools and further subclassifications of students within selected schools. Students from the different cells defined by the classification scheme were sampled with different probabilities of inclusion. In order to obtain accurate estimates of population values, analysts must thus use sampling weights which adjust the contributions of each case according to the number of other individuals in the sampled population represented by the case. All numbers presented in this report are calculated using the NELS:88 public-use weight named **F2PNLWT**. The subset of cases for whom this weight was defined consisted of the 16,489 students who participated in the 1988, 1990, and 1992 surveys. Unavailable when this report was completed but now included in the NELS:88 public release files, the **F2TRP1WT** weight variable is more appropriate for this analysis, since it is defined for base year-to-second follow-up students for whom transcripts were also successfully collected (n=14,283)

Sampling errors refer to the chance discrepancies between the population and a sample drawn from it. The size of the errors are inversely related to the sample size, but determining the true degrees of freedom is complicated when surveys use complex sample designs. The clustering and stratification used in the NELS:88 sampling design result in larger uncertainty of population estimates than would a simple random sample. All estimates, standard errors, and significance tests reported were thus calculated taking into account the sample design. This was done by multiplying the simple random sample standard errors by the average root design effect (DEFT) for the mathematics test completed by the 2nd follow-up panel sample, 2.273 (Ingels, et al., 1994, p. 53).

Other Analyses of NELS:88 Achievement and Course-taking Data. The NELS:88 achievement test and course work data can be analyzed in many different ways, depending on the purpose of the analysis. Various reports have been prepared or commissioned by NCES that illustrate different approaches to measuring achievement gain over time. In contrast to the approach of this report, which looks at types of course units completed and achievement gain scores, Hoffer, Rasinski, and Moore (1995) analyze the relationship of *numbers of course units completed* in math and science with the overall IRT scores, and break these down by the social backgrounds of the students. Rock, Owings, and Lee (1994) illustrate achievement gain analysis using mathematics *dichotomous proficiency scores* in conjunction with information on whether a student completed higher level math course sequences. Scott, Rock, Pollack and Ingels (1994) also illustrate achievement gain analysis in math using the continuous *probability of proficiency scores* in conjunction with information on specific course-taking sequences. In addition to the longitudinal use of the NELS:88 test data, other NCES reports (Rasinski, Ingels, Rock and Pollack, 1993; Green, Dugoni and Ingels, 1995) illustrate the use of NELS:88 cross-sectional results for measuring achievement trends over time through comparisons with earlier NCES longitudinal cohorts (NLS-72, and HS&B).

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Table 1:
Sample Counts and Percentages
By Highest Level of Mathematics Taken,
Base Year through Second Followup

	Basic Math	Algebra 1	Alg. 2 Geometry	Trig PreStat PreCalc	Calculus	Total*
Total Group						
Sample N	1071	1244	3432	2999	1390	10306
Weighted N	207215	220237	588972	453906	182455	1676786
Weighted %	12.5%	13.3%	35.6%	27.5%	11.0%	
Males						
Sample N	572	639	1636	1450	733	5103
Weighted N	116787	115838	289514	224702	97217	855363
Weighted %	13.8%	13.7%	34.3%	26.6%	11.5%	
Females						
Sample N	499	605	1796	154[illegible]	657	5203
Weighted N	90428	104399	299458	229204	85238	821423
Weighted %	11.2%	12.9%	37.0%	28.3%	10.5%	

* Includes students who could not be classified by course-taking.

Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1988 Base Year, 1990 First Followup, 1992 Second Followup and High School Transcripts.

Table 2a:
Average IRT-Estimated Number Correct
By Highest Level of Mathematics Taken,
Base Year through Second Followup

	Basic Math	Algebra 1	Alg. 2 Geometry	Trig PreStat PreCalc	Calculus	Total*
Total Group						
Base Year	25.72	29.09	34.78	43.05	52.04	37.04
First Followup	28.65	34.17	42.73	52.64	61.35	44.61
Second Followup	31.59	37.48	46.85	57.97	66.96	48.98
Gain: BY to F1	2.93	5.08	7.95	9.59	9.31	7.57
Gain: F1 to F2	2.94	3.31	4.12	5.33	5.61	4.36
Gain: BY to F2	5.87	8.38	12.07	14.92	14.91	11.93
Males						
Base Year	26.04	29.54	34.88	43.59	52.24	37.21
First Followup	28.47	34.72	42.84	53.37	61.76	44.73
Second Followup	31.85	38.50	47.65	59.21	67.55	49.59
Gain: BY to F1	2.43	5.19	7.96	9.78	9.52	7.51
Gain: F1 to F2	3.38	3.78	4.81	5.84	5.79	4.86
Gain: BY to F2	5.81	8.9[illegible]	12.77	15.62	15.31	12.38
Females						
Base Year	25.30	28.60	34.68	42.53	51.82	36.87
First Followup	28.88	33.55	42.63	51.92	60.88	44.50
Second Followup	31.25	36.34	46.08	56.76	66.28	48.34
Gain: BY to F1	3.58	4.95	7.95	9.39	9.06	7.63
Gain: F1 to F2	2.37	2.78	3.45	4.84	5.40	3.84
Gain: BY to F2	5.95	7.74	11.40	14.23	14.46	11.47

Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1988 Base Year, 1990 First Followup, 1992 Second Followup and High School Transcripts.

Table 2b:
Standard Error* of IRT-Estimated Number Correct
By Highest Level of Mathematics Taken,
Base Year through Second Followup

	Basic Math	Algebra 1	Alg. 2 Geometry	Trig PreStat PreCalc	Calculus	Total
Total Group						
Base Year	0.474	0.531	0.396	0.437	0.593	0.289
First Followup	0.579	0.638	0.448	0.428	0.481	0.333
Second Followup	0.623	0.663	0.434	0.415	0.477	0.348
Gain: BY to F1	0.404	0.462	0.274	0.281	0.379	0.161
Gain: F1 to F2	0.352	0.412	0.252	0.238	0.293	0.135
Gain: BY to F2	0.496	0.550	0.322	0.329	0.430	0.194
Males						
Base Year	0.662	0.746	0.573	0.632	0.843	0.416
First Followup	0.801	0.901	0.660	0.610	0.680	0.486
Second Followup	0.878	0.928	0.636	0.580	0.670	0.505
Gain: BY to F1	0.562	0.648	0.425	0.435	0.538	0.243
Gain: F1 to F2	0.490	0.600	0.387	0.358	0.401	0.199
Gain: BY to F2	0.699	0.759	0.493	0.499	0.619	0.289
Females						
Base Year	0.673	0.751	0.549	0.602	0.829	0.402
First Followup	0.837	0.896	0.609	0.598	0.676	0.456
Second Followup	0.874	0.933	0.589	0.581	0.670	0.478
Gain: BY to F1	0.571	0.659	0.350	0.359	0.532	0.212
Gain: F1 to F2	0.498	0.555	0.321	0.312	0.428	0.180
Gain: BY to F2	0.697	0.793	0.415	0.428	0.587	0.258

* Standard errors were adjusted for the average transcript design effect.

Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1988 Base Year, 1990 First Followup, 1992 Second Followup and High School Transcripts.

Table 3:
Probability of Proficiency: Level 2
(Operations with Decimals, Fractions, Powers, and Roots)
By Highest Level of Mathematics Taken,
Base Year through Second Followup

	Basic Math	Algebra 1	Alg. 2 Geometry	Trig PreStat PreCalc	Calculus	Total
Average Probability of Proficiency						
Base Year	0.07	0.16	0.38	0.71	0.92	0.46
First Followup	0.14	0.35	0.67	0.92	0.99	0.67
Second Followup	0.23	0.48	0.80	0.97	1.00	0.76
Gain: BY to F1	0.07	0.19	0.29	0.22	0.07	0.21
Gain: F1 to F2	0.09	0.13	0.13	0.05	0.01	0.09
Gain: BY to F2	0.16	0.32	0.43	0.27	0.08	0.30
Standard Error*						
Base Year	0.015	0.021	0.017	0.017	0.015	0.011
First Followup	0.022	0.028	0.017	0.010	0.005	0.010
Second Followup	0.026	0.030	0.014	0.006	0.003	0.009
Gain: BY to F1	0.018	0.025	0.015	0.015	0.014	0.008
Gain: F1 to F2	0.018	0.021	0.012	0.008	0.004	0.006
Gain: BY to F2	0.023	0.029	0.017	0.016	0.014	0.009

* Standard errors were adjusted for the average transcript design effect.

Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1988 Base Year, 1990 First Followup, 1992 Second Followup and High School Transcripts.

Table 4:
Probability of Proficiency: Level 4
(Intermediate Level Concepts; Solving Multi-Step Word Problems)
By Highest Level of Mathematics Taken,
Base Year through Second Followup

	Basic Math	Algebra 1	Alg. 2 Geometry	Trig PreStat PreCalc	Calculus	Total
Average Probability of Proficiency						
Base Year	0.00	0.00	0.02	0.09	0.31	0.07
First Followup	0.01	0.02	0.11	0.34	0.72	0.21
Second Followup	0.01	0.03	0.17	0.55	0.88	0.32
Gain: BY to F1	0.01	0.02	0.08	0.25	0.41	0.15
Gain: F1 to F2	0.01	0.02	0.07	0.21	0.16	0.10
Gain: BY to F2	0.01	0.03	0.15	0.47	0.57	0.25
Standard Error*						
Base Year	0.001	0.002	0.004	0.009	0.022	0.004
First Followup	0.005	0.006	0.009	0.016	0.022	0.008
Second Followup	0.007	0.009	0.012	0.018	0.017	0.010
Gain: BY to F1	0.005	0.006	0.008	0.013	0.021	0.006
Gain: F1 to F2	0.004	0.007	0.008	0.012	0.016	0.005
Gain: BY to F2	0.007	0.008	0.011	0.017	0.022	0.008

* Standard errors were adjusted for the average transcript design effect.

Source: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988 (NELS:88), 1988 Base Year, 1990 First Followup, 1992 Second Followup and High School Transcripts.